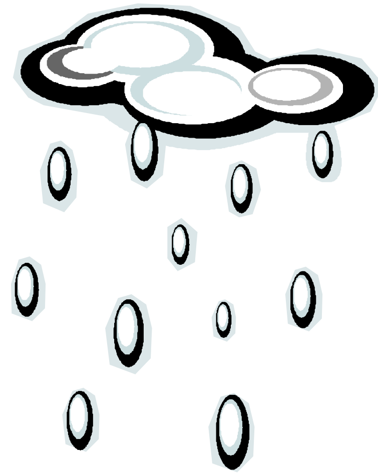
The Mystery of the SAV Die-Off of 2003

**Developed by Martha Shaum, Aquatic Resources Education Program,
Maryland Department of Natural Resources**



Overview: **Students use discharge data to correlate high runoff with the sudden rapid decline in SAV seen in 2003.**

Objectives:

Students will be able to :

- Access and use streamflow data to estimate levels of run-off through Chesapeake Bay tributaries.
- Analyze run-off data to determine possible relationships with SAV growth.
- Understand the effects of above or below normal precipitation on water quality, which in turn affects the survival of SAV.

Materials:

- Computers with internet access
- Student worksheet and data sheet
- Article from the *Bay Journal*, "Bay's SAV fell off almost 30% in 2003"

Grade Level: Middle School

Subject Areas: Environmental science, earth science

Duration: 45 minutes

Maryland Voluntary State Curriculum:

Middle School	1.A.1	Design, analyze, or carry out simple investigations and formulate appropriate conclusions based on data obtained or provided.
	1.B.1	Review data from a simple experiment, summarize the data, and construct a logical argument about the cause-and-effect relationships in the experiment.
Grade 6	3.F.1.a	Explain that populations increase or decrease relative to the availability of resources and the conditions of the environment.
Grade 7	6.B.1	Recognize and describe that environmental changes can have local, regional and global consequences.
Grade 8	3.D.1.a	Recognize and describe that gradual (climatic) and sudden (floods and fires) changes in environmental conditions affect the survival of organisms and populations.
	6.B.1	Recognize and explain how human activities can accelerate or magnify many naturally occurring changes.

Teacher preparation…

Use the following activities from the Chesapeake Choices and Challenges curriculum to teach the concepts of eutrophication and sedimentation:

- Please Don't Feed the Bay
- Sediment: Choking the Life of the Bay

Review previous lesson "Where, Oh Where, Should We Plant SAV?" to remind students of the most important factors that affect SAV growth (salinity, turbidity, chlorophyll, nutrients).

Teacher Background:

In 1983, when the first Chesapeake Bay Agreement was signed, there were only about 38,000 acres of SAV in the Bay, down from almost 200,000 acres believed to have existed until the middle of the 20th Century. At that time, the Chesapeake Bay Program set a goal of restoring 185,000 acres of SAV by 2010. By 2002, there were almost 90,000 acres, almost half the desired goal. But in 2003, the number of acres suddenly dropped to 64,700 acres, a decline of almost a third. This was the largest single-year decline since annual surveys began in 1984.

What caused this sudden, precipitous die-off? The previous four years were drought years, and as a result, there was less run-off carrying nutrients and sediment into the Bay. The year 2003 was the exact opposite – Maryland and Virginia both had the wettest year on record. (In Maryland, the average annual precipitation is 43 inches; in 2003 the average precipitation was 63 inches.) Huge amounts of nutrients had accumulated on land during the drought. The excess rain of 2003 washed these nutrients, along with sediment, into the Bay, fueling algae blooms and clouding the water. The increased turbidity blocked the sunlight needed by the SAV and the result was a massive die-off.

By 2005, the grasses had partially recovered to 78,200 acres, about 42% of the 2010 goal. Drought may be bad for farmers but the lack of rainfall may be good for the Bay. In many ways a drought helps SAV success by reducing run-off and improving water quality. Excessive rainfall, especially following a drought, rapidly degrades water quality.

Activity:

1. Read the following statement to your students:

> "In 1983, there were only about 38,000 acres of SAV in the Bay. The goal was to restore 185,000 acres by 2010. Gradually over the years, the number of acres increased, until in 2002, there were almost 90,000 acres of SAV – almost half the goal. But then suddenly in 2003, the number of acres dropped to 65,000 acres. This was a decline of almost a third and the biggest decline ever seen in a single year."
>
> - Adapted from Blankenship, Karl. "Bay's SAV fell off almost 30% in 2003." The Bay Journal June 2004: Vol. 14 No. 4

Make a timeline!

List the acreage of SAV for each date. Students will be able to visualize the decline in underwater grass.

2. Engage students in a brainstorming discussion. Record answers on the board or have students take notes.

   - Do you have any idea what might have caused such a sudden rapid decline?
     - What factor is the most important to the survival of SAV? *Turbidity.*
     - What might have caused a sudden increase in turbidity all over the Bay? What causes turbidity? *Excess sediment and algae blooms.* What often triggers algae blooms? *Excess nutrients.*
     - What might cause a sudden increase in sediment and nutrients in the water? Remember, whatever happened, it was wide-spread. *They may come to the conclusion that there must have been a lot of run-off.*
   - How can you find out if there was an exceptionally high level of run-off that year? *There are a number of gauges on rivers and streams all over the state that measure the amount of water going past. The amount of water is called "discharge". If the discharge is high, the run-off is high.*

Note: Make sure the students understand the definition of discharge - the amount of water in a stream or river going past a given point in a given moment in time. It is expressed as a volume per unit time (e.g., gallons per minute or cubic feet per second).

For more information on streamflow or discharge, go to
http://ga.water.usgs.gov/edu/measureflow.html

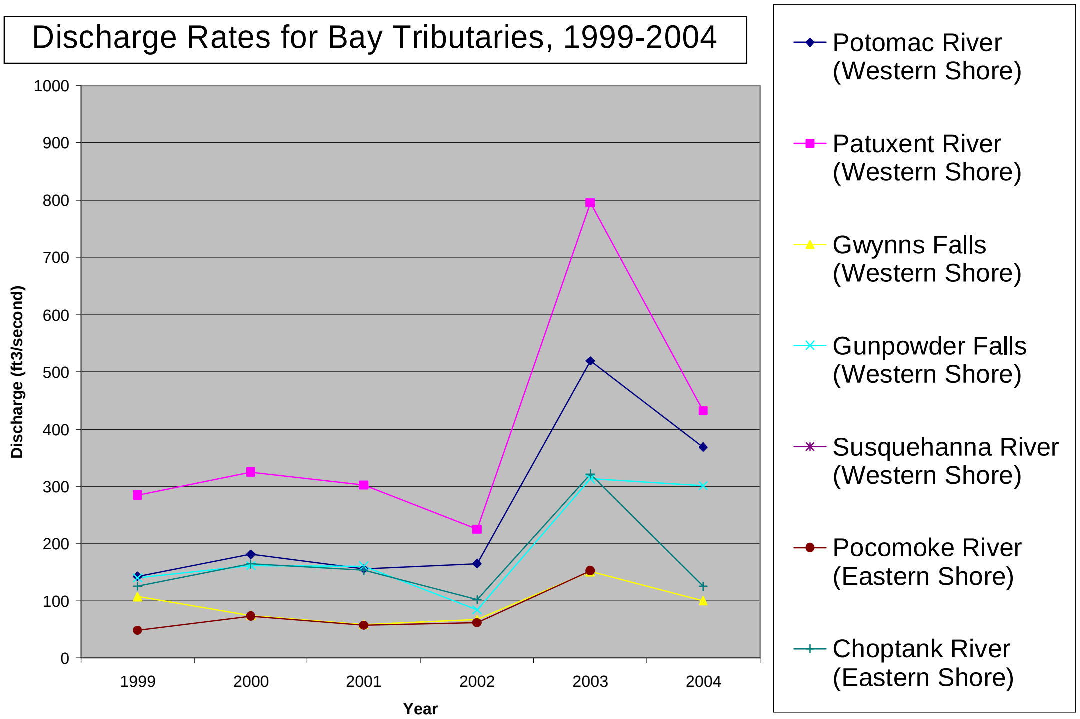
3. Allow students to access the information from state-wide discharge gauges online. Divide the students into groups depending on the number of available computers. Hand out the student worksheet. It will explain how to access and record the data. Students can use that data to check their hypothesis about the reason for the SAV decline in the Bay.

4. Have the students read the article from the *Bay Journal* to confirm their conclusion and help them answer the analysis questions.

Answers to Student Worksheet:
State your hypothesis:
What probably caused SAV beds to decrease by almost 1/3 in 2003? *Excessive runoff probably caused increased turbidity, which blocked sunlight and prevented the grass beds from photosynthesizing.*

Results:

Location	Discharge in Cubic Feet per Second					
	1999	2000	2001	2002	2003	2004
Potomac River (Western Shore)	*142.5*	*181.0*	*155.5*	*164.7*	*519.2*	*368.5*
Patuxent River (Western Shore)	*284.5*	*324.5*	*302.0*	*224.6*	*795.3*	*431.6*
Gwynns Falls (Western Shore)	*107.2*	*74.2*	*58.6*	*66.7*	*150.8*	*99.9*
Gunpowder Falls (Western Shore)	*140.0*	*161.3*	*160.2*	*84.0*	*312.9*	*300.8*
Susquehanna River (Western Shore)	*26830*	*34350*	*23560*	*33390*	*60680*	*65540*
Pocomoke River (Eastern Shore)	*48.1*	*73.2*	*56.8*	*61.6*	*152.6*	*N/A*
Choptank River (Eastern Shore)	*125.3*	*164.1*	*152.8*	*102.1*	*321.7*	*125.0*



It may be helpful for your students to graph their data. Here it is very easy to see the dramatic change in discharge between 2002 and 2004.

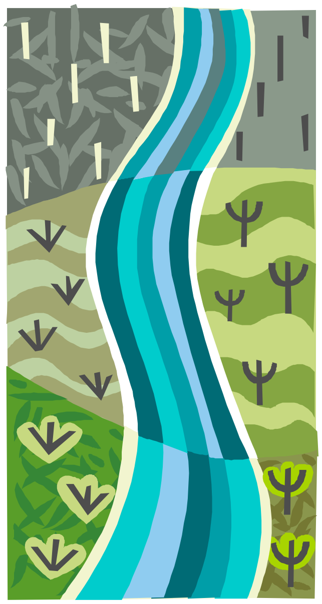
Analysis

1. Do the data support your hypothesis? Why or why not? *They should see that in rivers on both sides of the Bay, the discharge for 2003 was much higher than it had been in the previous four years. This should support their hypothesis.*

2. From 1999 to 2002, a drought occurred in Maryland. The following year (2003) was the wettest year ever recorded in both Maryland and Virginia. How would several years of drought impact the effects of the exceptionally wet year that followed? *The impact of the wet year was made greater by the fact that it had been so dry for the previous four years. The soil would have been drier than normal and more easily washed away. In addition, the fertilizer (nutrients) put on the fields during the drought probably would have accumulated instead of running off. Then in 2003, all the accumulated nutrients would have washed into the Bay all at once.*

3. Obviously, humans have no control over the weather. What steps could they take to lessen its impacts? *Plant buffer strips, restore wetlands, plant rain gardens, use rain barrels, etc. – anything that will slow run-off. Reducing nutrients by fertilizing your lawn less often, etc. will decrease the amount of nitrogen and phosphorous that reaches the bay and causes algae to cloud the water.*

The Mystery of the SAV Die-Off of 2003



Student Worksheet

Read the following statement as a class or on your own:

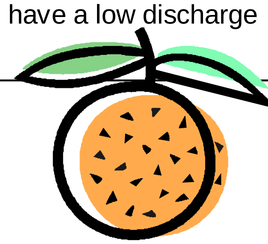
> "In 1983, there were only about 38,000 acres of SAV in the Bay. The goal was to restore 185,000 acres by 2010. Gradually over the years, the number of acres increased, until in 2002, there were almost 90,000 acres of SAV – almost half the goal. But then suddenly in 2003, the number of acres dropped to 65,000 acres. This was a decline of almost a third and the biggest decline ever seen in a single year."
>
> - Adapted from Blankenship, Karl. "Bay's SAV fell off almost 30% in 2003." The Bay Journal. June 2004: Vol. 14 No. 4

Your task is to solve the mystery of this sudden die-off of SAV that occurred in 2003.

State your hypothesis:
What probably caused SAV beds to decrease by almost 1/3 in 2003?

Procedure:
To complete your task, you are going to analyze data collected by USGS. This data measures stream discharge.

Imagine if you were to drop an orange in a stream. If the orange moved quickly downstream, that stream would have a high discharge rate. If the orange moved slowly, the stream would have a low discharge rate.



Discharge is defined as the amount of water in a stream or river going past a certain point during a given moment in time. It is expressed as a volume per unit time – for example, gallons per minute or cubic feet per second. The data you will be using measure discharge in cubic feet per second.

Keep in mind that a high discharge rate usually means a lot of rainfall, which means there is going to be a lot of runoff coming from the surrounding watershed. Too much runoff will increase the turbidity of the stream or river.

To access the USGS real-time water data:

1. Go to http://nwis.waterdata.usgs.gov/md/nwis/rt.
2. On the right side, click on “Statewide Streamflow Table”.
3. Scroll down to where the river basins are listed. Find “Potomac River Basin (Harper’s Ferry to Washington)”.
4. Click on “01646500 POTOMAC RIVER NEAR WASH, DC LITTLE FALLS PUMP STA”.
5. Click the “Available data for this site” drop-down menu to select “Time-series: Annual statistics”.
6. Check the box for Parameter Code – 00060 “Discharge, cubic feet per second”
7. Under “Choose Output Format,” type 1999 to 2004 for the “Date range”, and choose “Annual statistics based on Calendar Year”.
8. Click “Submit”

This will give you the discharge data for the Potomac River. Enter this in the data table.

Go back to Statewide Streamflow Table page (step 2) and collect discharge data for the rest of the sites:

Patuxent River Basin: click on “01594440 PATUXENT RIVER NEAR BOWIE MD”
Patapsco River Basin: click on “01589352 GWYNNS FALLS AT WASHINGTON BLVD AT BALTIMORE MD”
Gunpowder River Basin: click on “01582500 GUNPOWDER FALLS AT GLENCOE MD”
Susquehanna River Basin: click on “01578310 SUSQUEHANNA RIVER AT CONOWINGO MD”
Chesapeake Bay Drainage-Eastern Shore: click on “01485000 POCOMOKE RIVER NEAR WILLARDS MD”
Chesapeake Bay Drainage-Eastern Shore: click on “01491000 CHOPTANK RIVER NEAR GREENSBORO MD”

For each site, be sure that you choose:

Available data – Time series: Annual statistics
Parameter code 00060 Discharge, cubic feet per second
Date range – 1999-2004
Annual statistics – calendar year

Results

Enter all data in the data table.

Analysis

1. Do the data support your hypothesis? Why or why not?

Hint: it may be helpful to graph your data in order to see any dramatic changes in discharge rates.

2. From 1999 to 2002, a drought occurred in Maryland. The following year (2003) was the wettest year ever recorded in both Maryland and Virginia. How would several years of drought impact the effects of the exceptionally wet year that followed?

3. Obviously, humans have no control over the weather. What steps could they take to lessen its impacts?

Data Table: The Mystery of the SAV Die-Off of 2003

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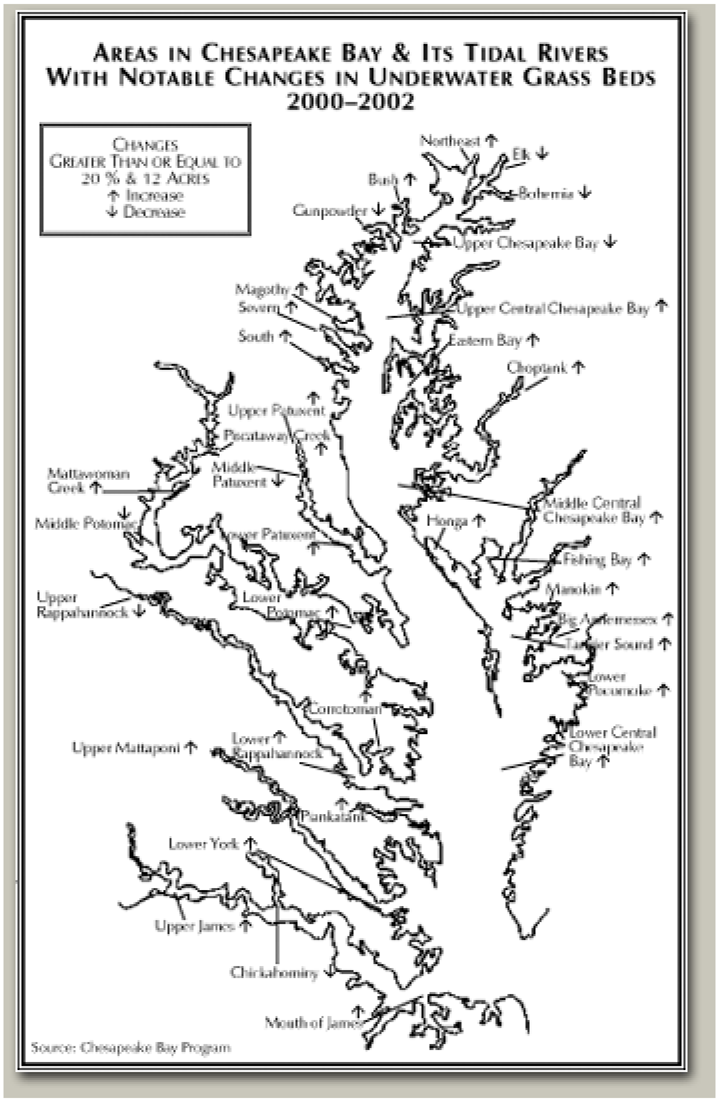
Choptank River (Eastern Shore)						

Bay's SAV fell off almost 30% in 2003
From The Bay Journal, June 2004, Volume 14 - Number 4
By Karl Blankenship



Last year's poor water quality, driven by near-record river flows, wiped nearly a third of the Chesapeake's underwater grass beds from the map, more than offsetting the large gains observed during the proceeding four years of drought.

Overall, the amount of Bay grasses decreased almost 30 percent last year, from 89,659 acres in 2002 to 64,709 acres. It was the largest single-year decline since annual aerial surveys of the grass beds began in 1984.

Scientists blamed the die-off on the higher than normal precipitation which drove huge amounts of nutrients and sediment into the Bay, blotting out the sunlight crucial to the plants.

And, they said last year's events raise questions about whether the Bay can sustain significantly increased acreage of grass beds until much more is done to reduce pollution.

"When you look at the total Bay grass acreage, we are down to where we were more than a decade ago," said Mike Naylor, a biologist with the Maryland Department of Natural Resources.

"I think it really highlights the fact that except for the Upper Bay, where we have had a slow upward trend, we really have made minimal progress in the last decade toward achieving our goals," Naylor said.

The Bay Program last year set a restoration goal of 185,000 acres of submerged underwater vegetation, or SAV, by 2010. Achieving the water quality needed to support those grasses was part of the basis for new nutrient and sediment reduction goals set for the region last year.

But instead of decreasing, the amount of nutrients and sediment entering the Bay rose sharply in 2003. Data from the U.S. Geological Survey show that the Bay's nine largest tributaries delivered three times as much nitrogen, five times as much phosphorus and 11 times as much sediment to the Bay compared with 2002.

That's bad news for grasses. Like all plants, they need light to survive, but sediment clouds the water, and nutrients spur algae blooms as well as the growth of epiphytes directly on blades of grass, all of which blocks sunlight.

Naylor said last year's high flows resulted in a "systemwide decrease in water quality." In many places, he said, water clarity was the worst on record, and the densities of the algae blooms were the highest ever reported.

"Nature continually reminds us that SAV is very sensitive to water quality," said Bob Orth, of the Virginia Institute of Marine Science, who oversees the annual aerial survey. "Acreage fluctuations over the past two years reinforce the message that SAV can rapidly rebound when conditions improve, but also decline just as rapidly when conditions worsen as they did in 2003."

Because of their tight link to water quality, the amount of grasses is one of the most closely watched indicators of how the Bay is doing. They are also one of the most critical components of the Bay ecosystem. Grass beds pump oxygen into the water, trap sediments, provide food for waterfowl and shelter for fish and blue crabs. Densities of juvenile blue crabs may be 30 times greater in grass beds than nearby barren areas.

Last year, grasses declined in all major regions of the Chesapeake:

The Upper Bay, from the Susquehanna River south to the Chester and Magothy rivers, decreased by about 20 percent, from 13,166 acres in 2002 to 10,416 acres.

The Middle Bay, from the Bay Bridge south to the Rappahannock River, decreased by about 41 percent, from 52,973 acres to 30,475.

The Lower Bay, from the Rappahannock River and Pocomoke Sound south to the Bay's mouth, decreased by 12 percent, from 23,520 acres to 20,802.

Not all of the news was bad. Orth said he was impressed that steady increases over the last decade were maintained in some areas, such as the Severn, Magothy, Middle and Upper Patuxent rivers.

But losses in the Middle Bay are particularly troublesome because scientists say grass beds in that region are particularly important for juvenile blue crabs.

Scientists said much of the drop was caused by the disappearance of widgeon grass in the Middle Bay, a species notorious for wide year-to-year fluctuations.

Widgeon grass is considered a "pioneer" species that can quickly colonize an area when conditions are right, but is less able to withstand setbacks caused by poor water quality. Most of the gains in underwater grasses since the mid-1990s have been the result of widgeon grass regrowth.

"We've seen it before," Orth said. "the plant grows like a weed, and it probably will rebound quite quickly in some of these areas, as long as we don't have a bad year."

He and others said the dramatic fluctuations in widgeon grass point to the need to restore not only the grass beds, but also the historic diversity of species once found within many of those beds.

"You like more species because they can respond very differently to water temperature and light, so if one goes down, the other might go up," Orth said. "I think there is a need to look carefully at the diversity issue."

Peter Bergstrom, a fishery biologist with the National Oceanic and Atmospheric Administration's Chesapeake Bay Office, said he reviewed historic ground survey records of SAV species found in grass beds in Maryland from 1971–1990. In areas which are now dominated by widgeon grass, he said, the records show at least one other species was present in previous decades—and sometimes two or three other species were found.

"When widgeon grass started to come back in the late 1980s and early 1990s," he said, "usually, those other species didn't come back with it."

If so, a key challenge is maintaining good conditions for enough years so that species which colonize more slowly can eventually merge into widgeon grass beds. "I think the message is that we need to improve the water quality so that something besides widgeon grass can grow," Bergstrom said.

But more bad news from 2003 may emerge when this year's aerial survey is completed. Last year's data do not reflect any impact form Hurricane Isabel which hit in late September. Most of the aerial survey had been completed before the hurricane hit.

Initially, scientists thought the late-season hurricane was likely to cause only a little damage to SAV beds, as it hit after the growing season. But Orth said on-the-ground surveys early this year showed "significant" losses in some areas, such as the mouth of the York River, although other areas appear to have been spared.

"It's a mixed message, but there is definitely a significant loss at the mouth of this river," he said.

Scientists believe 200,000 acres or more of grass beds once covered the Bay, providing huge amounts of habitat for an array of species. But Bay Program efforts to track down historic aerial photographs of the Chesapeake show a steady decline in acreage over the decades as increased amounts of pollution washed into the estuary.

Hurricane Agnes in 1972 was the biggest shock to the grass beds, causing sharp Baywide declines. Grasses bottomed out at an estimated 38,000 acres in 1984, and slowly increased until the 1990s, when acreages leveled off in the 60,000– to 70,000-acre range. Four years

of drought conditions starting in 1999 dramatically reduced nutrient and sediment pollution to the Bay, causing grasses to surge to 89,659 acres in 2002—the most observed in recent history.

The Bay Program's annual Baywide grass estimate, undertaken by the Virginia Institute of Marine Science, is derived from an analysis of more than 2,000 black-and-white aerial photographs taken between May and October.

Karl is the Editor of the Bay Journal.